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EERA DTOC
THE EUROPEAN ENERGY RESEARCH ALLIANCE
DESIGN TOOLS FOR OFFSHORE WIND FARM CLUSTER

Support by

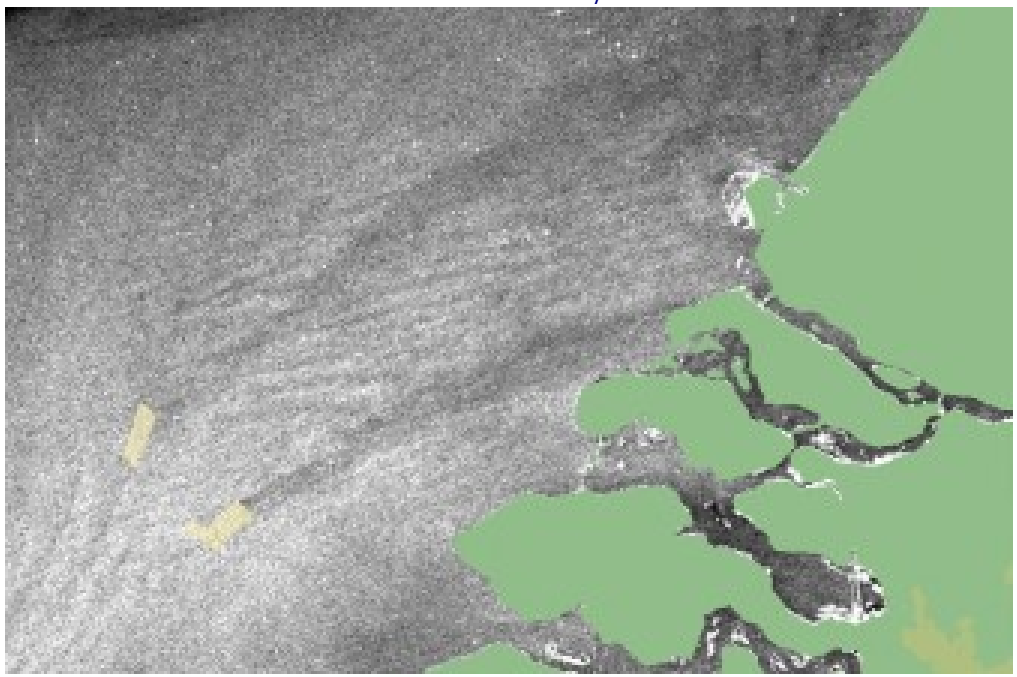
Introduction

Our aim is to understand better wakes of wind farms, especially their:

(1) Properties
- Depth
- Extension
- Dynamics

(2) Long-term impact on
- Wind resources
- Environment (T, Q)

Wakes behind Belwind/Thornton

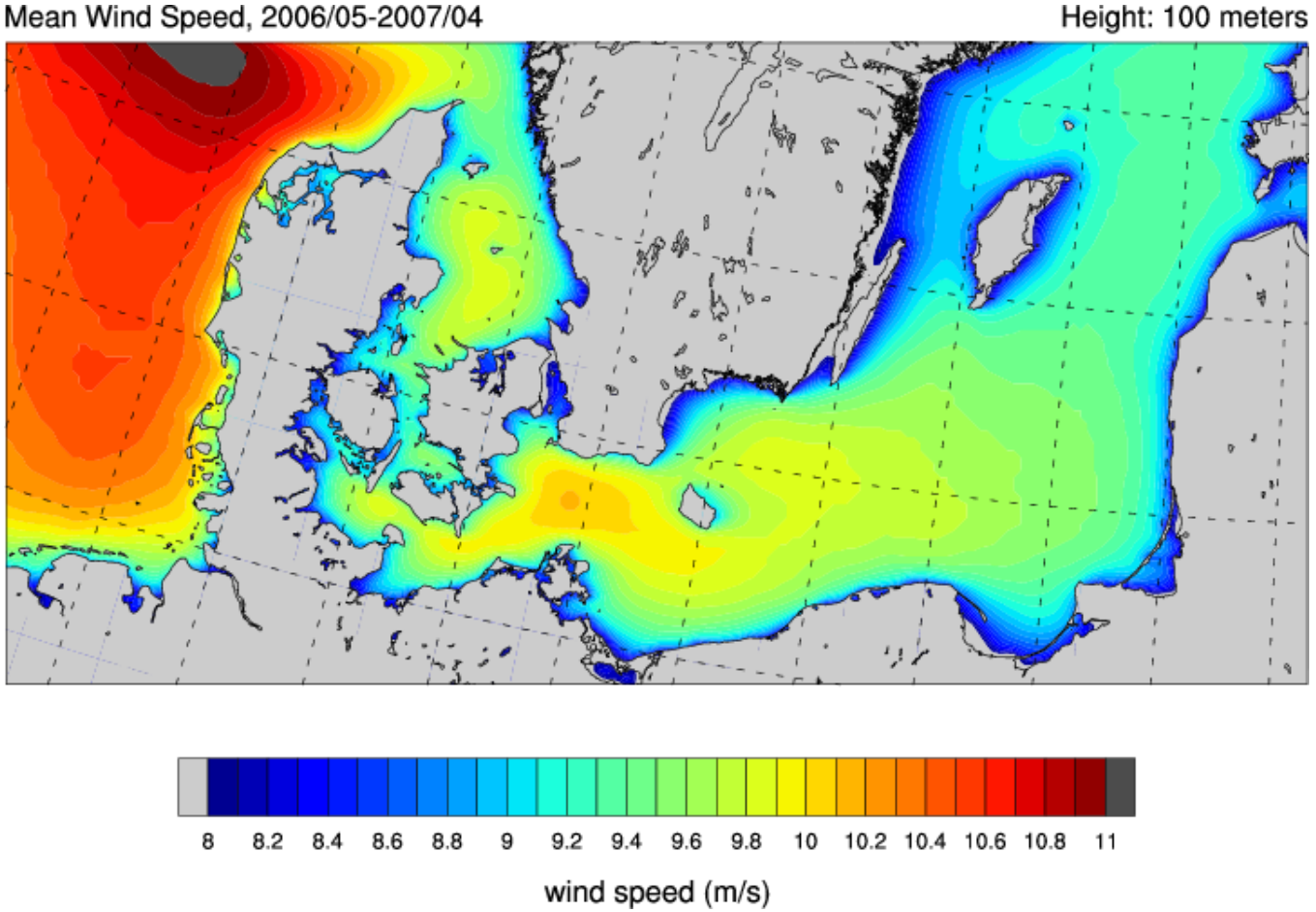


Content:

1) Mesoscale models
2) EERA-DTOC Project
3) Mesoscale models in EERA-DTOC

Mesoscale Model (General)

Mesoscale models are used for:
- Forecasting the weather
- Wind resource assessment



Weather Research and Forecast model (WRF)
2.750.000 Cells for an area $\approx$ 180.000 km^2
On our cluster: 2/3 Days per year on 70 X 20 processors

Wind Farm Parametrisations

WRF Wind Farm scheme (Fitch et al. 2012):

(1) Local drag force (Rotor swept area)

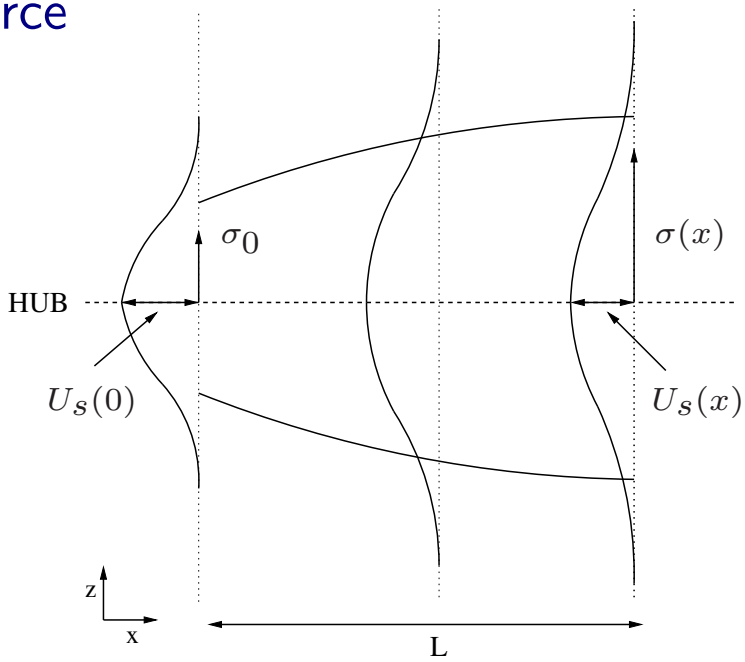
(2) Additional TKE source term

Explicit Wake Parametrisation (EWP) approach:

(1) Accounts for unresolved wake expansion

(2) Applies Grid-cell averaged drag force

Concept:



Sketch of the wake development within a grid-cell

For both schemes the full TKE budget is calculated by PBL-scheme

EERA-DTOC Project

EERA-DTOC (Seventh Framework Programme (FP7)):
European Energy Research Alliance - Design Tool for Offshore Wind Farm Cluster

"Integrated and validated design tool combining state-of-the-art wake, yield and electrical models"

Universities/Institutes:

- DTU Wind Energy (Denmark)
- ECN (Netherlands)
- Universität Oldenburg (Germany)
- Fraunhofer (Germany)
- CRES (Greece)
- CIEMAT (Spain)
- CENER (Spain)
- CLS (France)

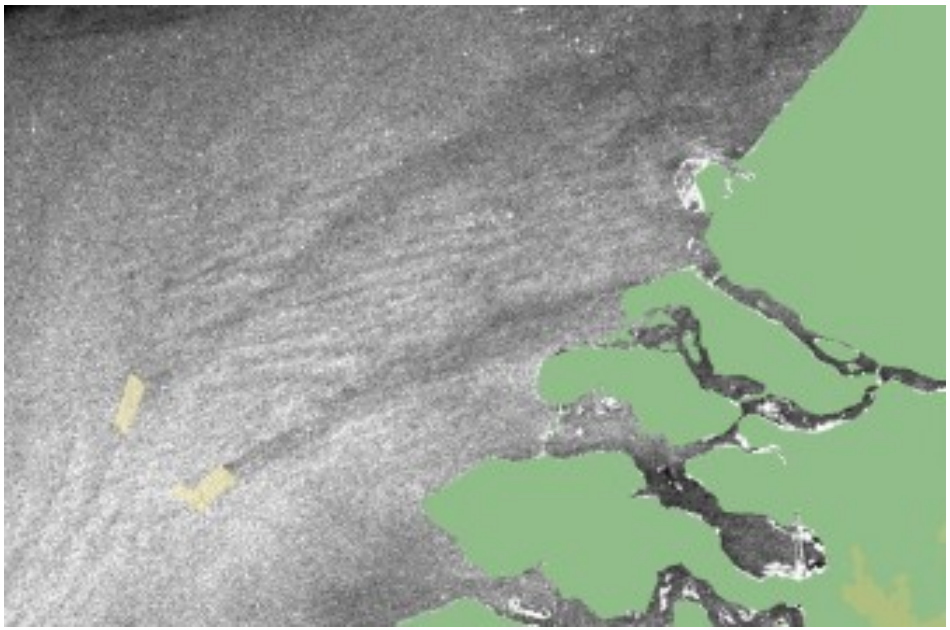
Industry:

- Carbon Trust (United Kingdom)
- RES (United Kingdom)
- Overspeed (Germany)
- Statoil (Norway)
- Statkraft (Norway)
- Iberdrola (Spain)
- EON (Sweden)

DTOC - Mesoscale Model Evaluation

Qualitative comparison with Synthetic Aperture Radar (SAR) images. They can retrieve wind speed from back-scatter (higher wind speeds are brighter):

SAR Image (17:34 UTC)



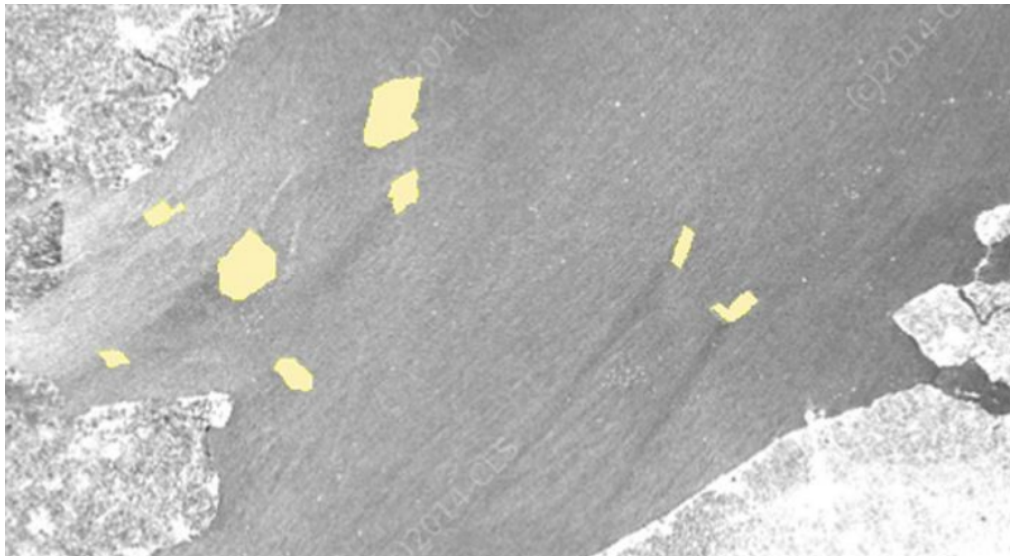
WRF-EWP (17:30 UTC)

1st of July of 2013: Belwind &Thornton

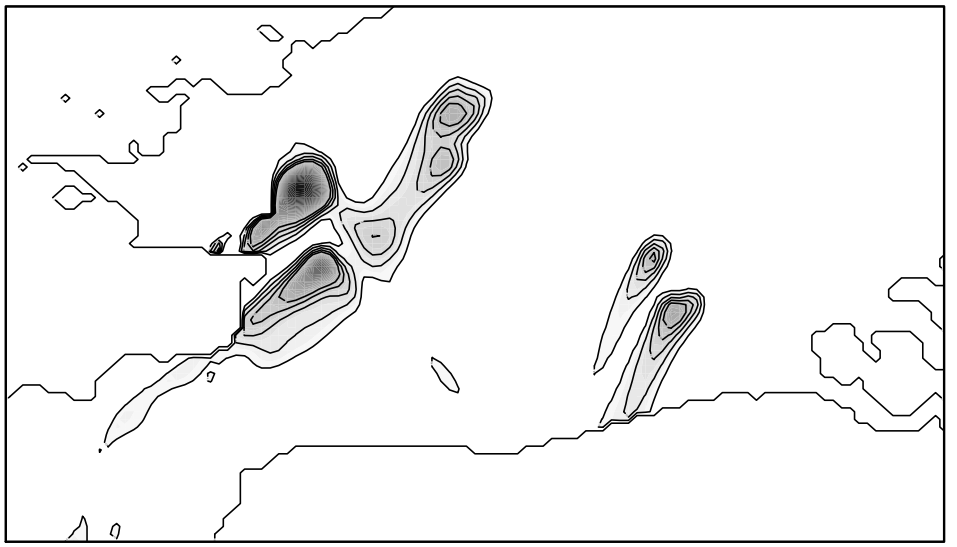
⇒ Comparable extension and divergence

DTOC - Mesoscale Model Evaluation (cont'd)

SAR Image (17:41 UTC)



WRF-EWP (18:00 UTC)

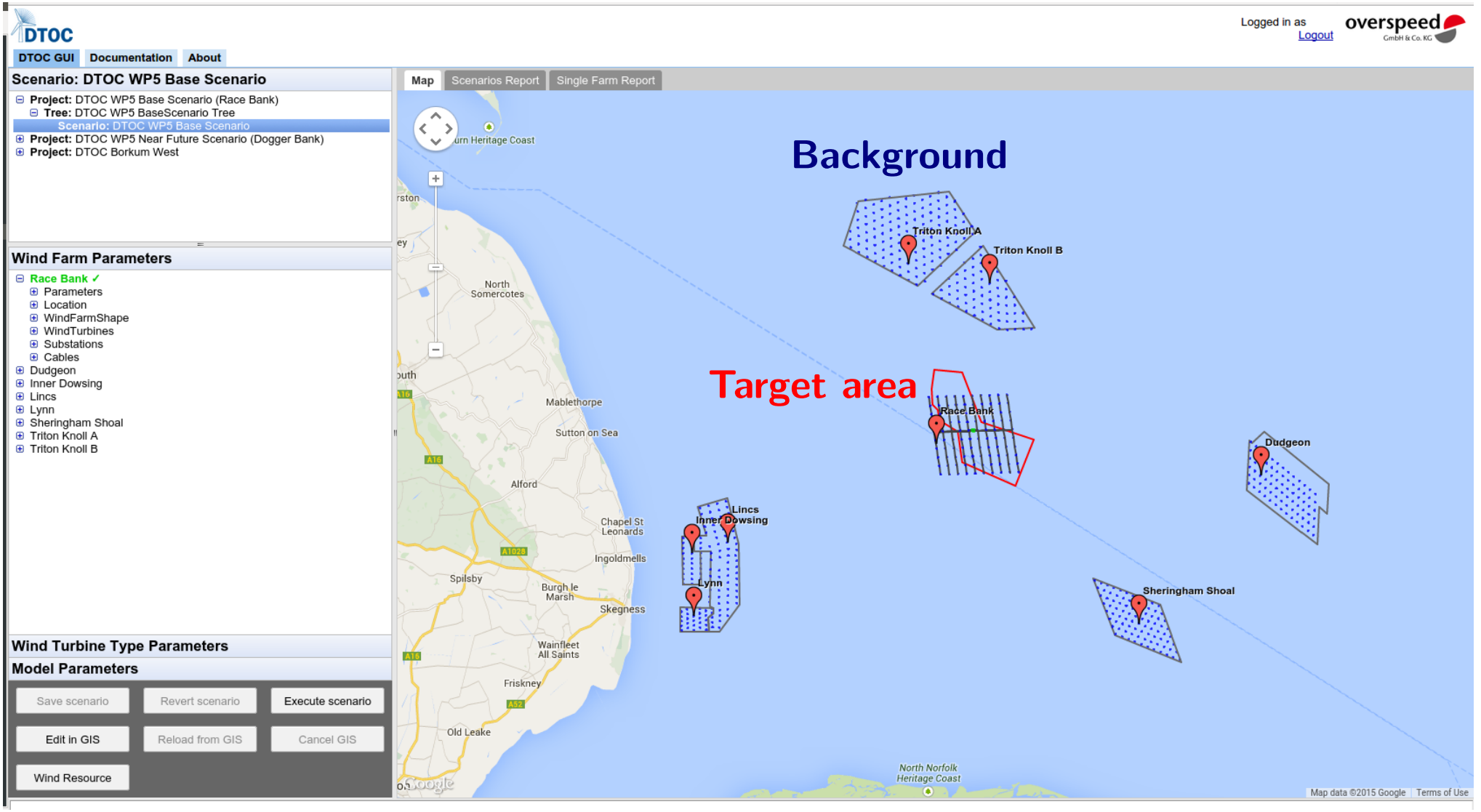


30th of April 2013: UK wind farms and Belwind &Thornton

$\Rightarrow$ Challenge in timing snap-shots

DTOC - User Interface

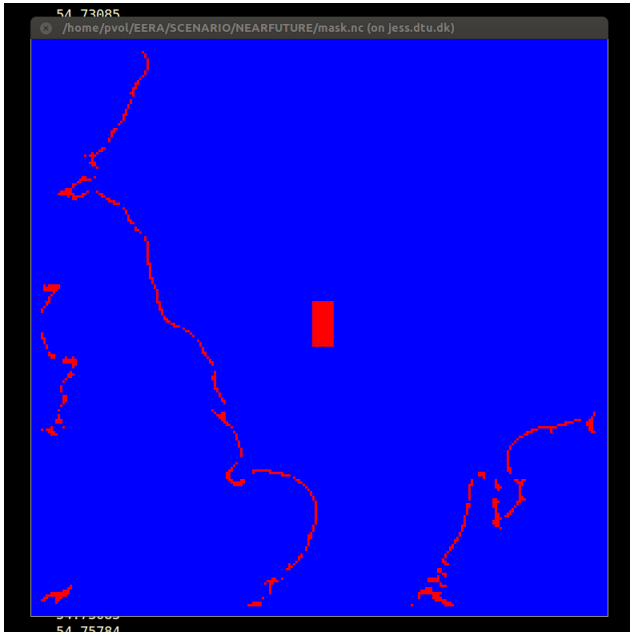
Wind climate in the **target area** from WRF with/without **background** wind farms



Outcome: Annual Energy Production of the target wind farm accounting for wake losses of neighbouring wind farms

DTOC - Mesoscale Model Implementation

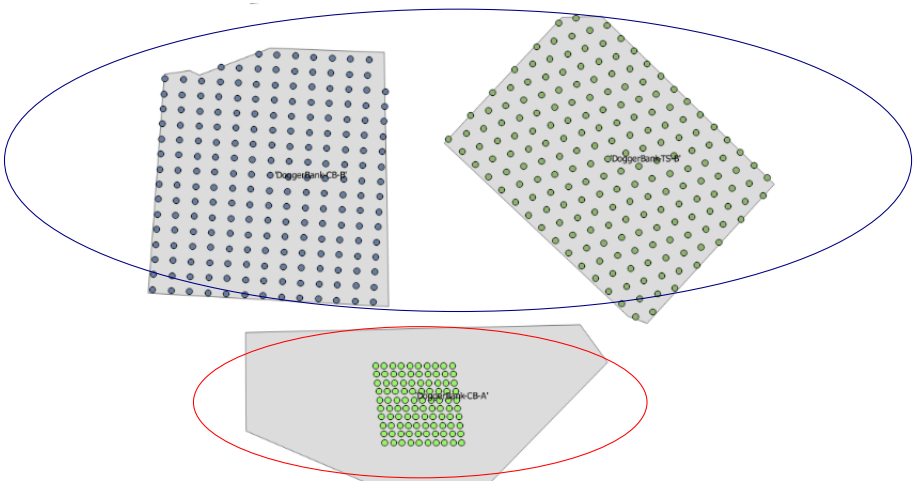
Three institutes (CENER, CIEMAT and DTU) can calculate a Wind Climate for a **target area**



Without and with **background** wind farms

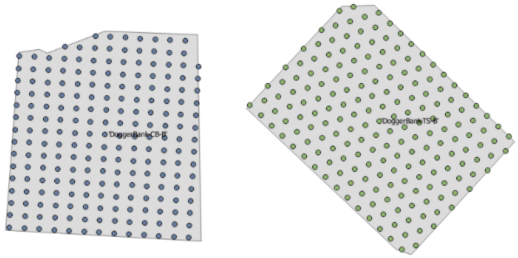
Background

Target area



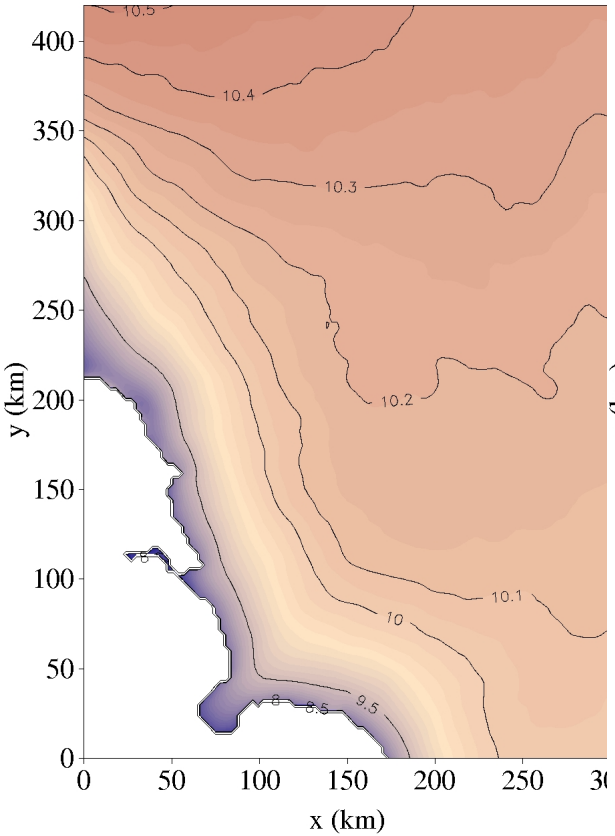
DTOC - Mesoscale Model Implementation

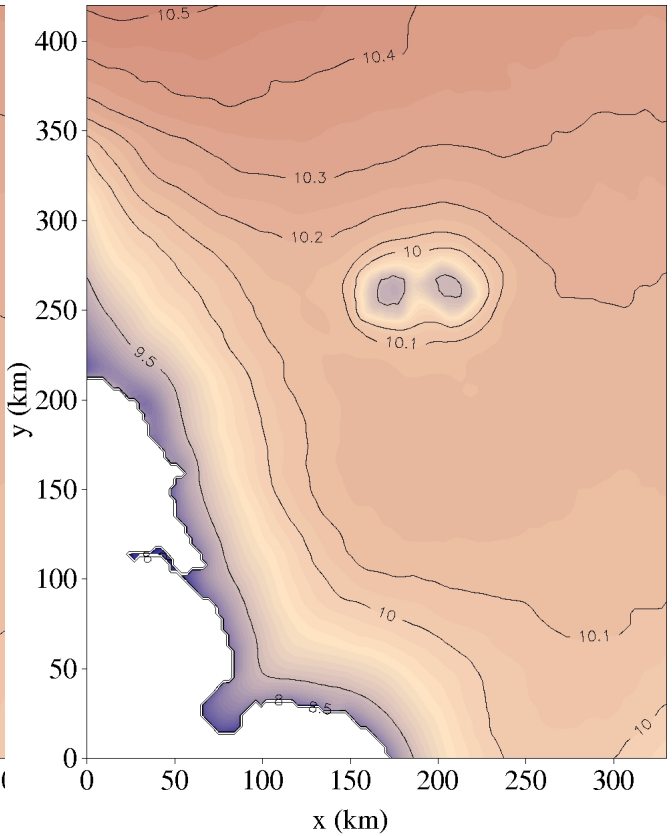
2 years simulation with WRF-EWP in the North-Sea without/with **background** wind farms

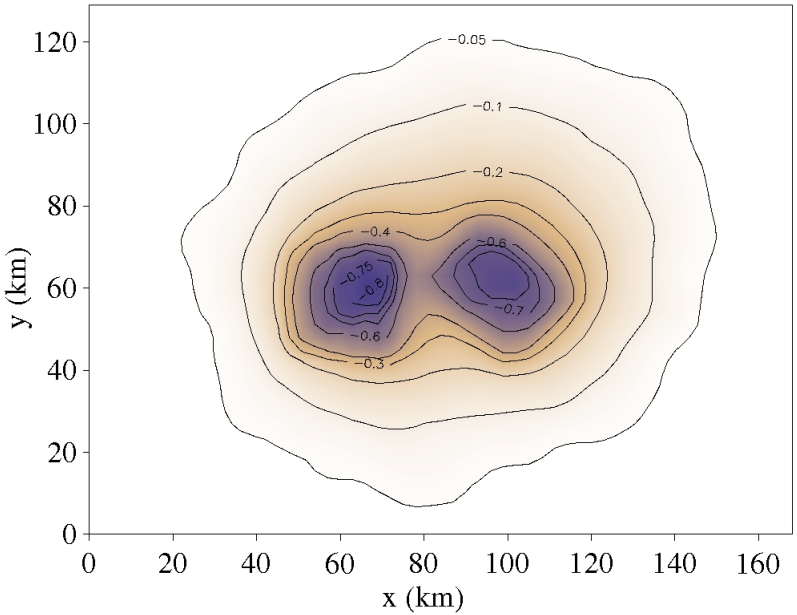


Time averaged wind speed at hub-height (119 m)

Reference **Wind Farm** **Difference** (0.05 – 0.8 m/s)



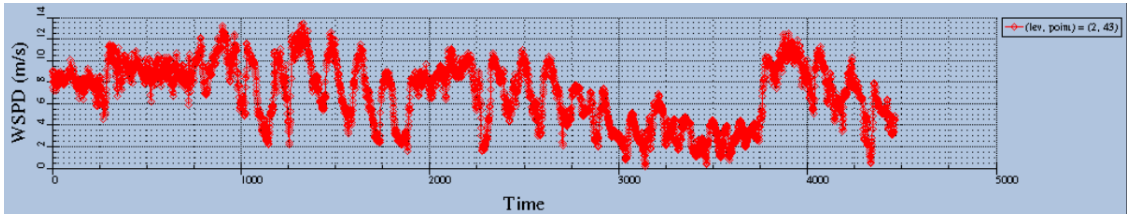


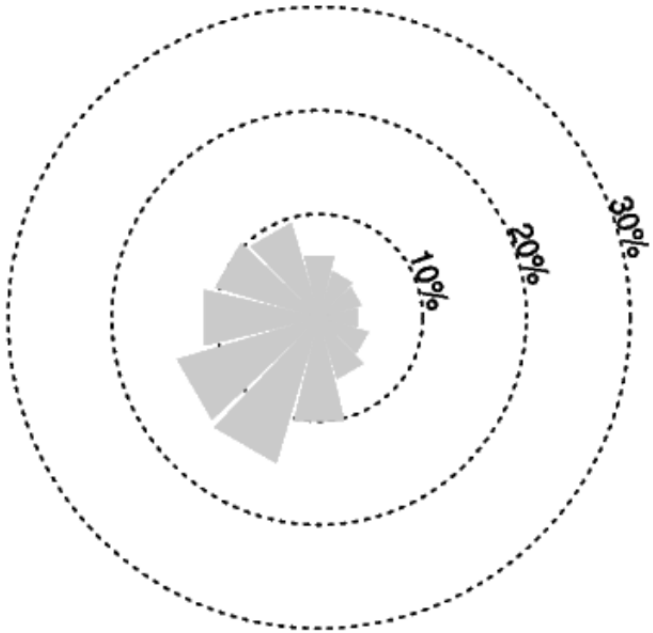


DTOC - Mesoscale Model Implementation

The Mesoscale model provides for all point within the **target area** in a given **period**:

- Time-Series
- Modelled Wind Climate
- Generalised Wind Climate (DTU)





Summary

Within the EERA-DTOC tool:

- Methodology has been implemented in the DTOC-TOOL
- Neighbouring wind farms can now be accounted for in time-series and the wind climate

$\Rightarrow$ Annual Energy production for a new wind farm for the Wind climate with/without neighbouring wind farms

Mesoscale models:

- Have the capability to accounts for the dynamics in the wind farm wake
- Further investigation of the long-term velocity reduction is needed

Support by

This project has received funding from the European Union's Seventh Programme for research, technological development and demonstration under grant agreement No FP7-ENERGY-2011-1/ n°282797